Appendix A – Collaborative Decision Making (CDM)

Collaborative Decision Making (CDM) refers to a specific FAA program that is managed by AUA-700, sponsored by the Air Traffic Control System Command Center (ATCSCC), and formally known as CDM-Ground Delay Enhancements. The program implements a philosophy of business conduct between the various components of aviation transportation, both government and industry.

CDM has a very narrow focus: reduced airport arrival capacity, and specifically, those situations that usually lead to some kind of ground delay program, or ground hold strategy. There are two central tenants to CDM:

- Better information will lead to better decision making
- Tools and procedures need to be in place to enable ATCSCC and the NAS users to more easily respond to changing conditions

This briefing covers the background of the program, participant roles and responsibilities, how CDM works (with descriptions of the primary program elements), a summary of the FAA's benefits calculations, and a look at CDM in the 2003 – 2005 time frame.

A.1 Background

Since the early 1990s representatives from the government, several airlines, and private industry have been trying to determine whether the concept of CDM might benefit Traffic Flow Management (TFM) by looking at the questions of:

- Who should be involved and how
- What data would be available and whether and how it could be used
- Whether the results and benefits support the costs of such a program

Although this program officially became CDM in the spring of 1995, it began when Air Traffic Management (ATM) commissioned the Mitre Corporation to analyze the existing substitution process and suggest improvements to that process. Mitre developed a prototype system known as the Ground Delay Substitutions Visualizer (GSubV) which contained alternative substitution mechanisms and became an early prototype of the flight compression process the is now part of the CDM's Flight Schedule Monitor (FSM) software.

In the summer of 1993 the FAA / Airline Data Exchange (FADE) program was initiated during a Traffic Flow Management -Architecture Requirements Team (TFM-ART) meeting. FADE was to be a short experiment focusing on whether updated schedule information provided by the NAS users could affect Traffic Flow Management decision-making. FADE-related experiments proved that this type of information exchange would have a positive impact on TFM decision making, which led to the continuation of FADE and its evolution into CDM.

Numerous statistical and simulation analyses were conducted in early 1994 in an attempt to quantify the benefits of the data exchange and the new processes/ substitution rules being proposed in the FADE program. In August 1994 an extensive 3-week human-in-the-loop exercise was conducted with ATCSCC focusing specifically on whether updated schedule information could influence decision-making. The findings showed that decision-making can improve with improved information.

In December of 1994 a joint airline/ATCSCC war game exercise was conducted at Metron Aviation Inc. in Reston, VA. A timing cycle was exercised and the combined effects of improved decision making and the new compression process were measured. Total delay reduction was quite consistent with the ATCSCC exercise, ranging from less than 10 percent to more than 35percent, depending upon the airport scenario. Many airline representatives regarded the ORD scenario in the war game as the strongest evidence of the potential benefits of CDM. During this scenario the research team used the actual weather conditions (snowstorms) in Chicago occurring on the day of the war game. Two major carriers, using laptops and modems, used actual cancellations that they extracted from their operational control centers. The approximate 20percent reduction in delay could then be directly compared with the actual GDP and substitutions that were taking place at the exact same time we were conducting the war game.

In early 1995 several meetings took place at the ATA with airline representatives and the FAA/FADE program manager to develop what became known as "Roles and Responsibilities." These were in time signed off by both the development and Air Traffic arms of the FAA. The principle focus of these roles and responsibilities is considered by many to be the cornerstone of collaboration; a mutual respect and understanding of the respective roles of the service provider (ATCSCC) and the NAS users. ATCSCC 's principle role is to identify bottlenecks and constraints and communicate these to the users. The user's role is to operate within these constraints and communicate their intentions to the provider. With respect to GDP, the constraints are in the form of Airport Acceptance Rates (AARs) and once a program is run, allocated arrival slots. User intentions are reflected in schedule changes and, when a GDP has been run, slot substitutions.

By the spring of 1995 the program was given its present name, CDM, and the CDM working group was formed. The group consists of numerous airline representatives, the ATA, representatives from ATCSCC, the TFM Integrated Product Team (IPT) (AUA-700), as well as FAA contractors and the Mitre Corporation. The CDM group is co-chaired by the FAA Program manager from the IPT and an airline representative. In the summer of 1995 many of the CDM participants were involved in the RTCA Free Flight Task Force III, and were instrumental in getting the free flight definition expanded to include strategic planning and specifically, collaboration and information exchange. By the fall of 1995 the program became better defined. Volpe National Transportation Systems Center produced a program plan, system requirements document, and detailed description of the CDM message formats. CDM members began work on the tools needed to effect a smooth transition to a new NAS.

By the summer of 1997, CDM had created the AOCnet, which allowed eight major airlines to send dynamic scheduling information to the FAA's ATCSCC. The program also began the transition to RTCA Special Committee 191 – Collaborative Air Traffic Management. CDM remained a working implementation group with RTCA SC 191 providing support with documentation and concept development.

Using both the AOCnet and FSM, beginning in January 1998 CDM began prototype operations of GDPE.

A.2 Roles and Responsibilities

The cornerstone of CDM is the "Roles and Responsibilities" document, which was signed by the FAA's Development and Air Traffic entities early in 1995. This document defines the division of responsibility as follows:

- Air Traffic Control – Traffic Flow Management (ATD-TFM)
- Monitor the National Airspace System (NAS) for constraints that produce capacity and demand problems (e.g., runway closures, weather fronts)
- Make these constraints known to NAS users
- In cooperation with the users, develop a baseline solution to the problem created by the constraint
- Airline Operational Control (AOC)
- Keep ATC-TFM informed of current operational demand and intent
- Provide airline business need plans and designs within the general baseline solution provided by ATC-TFM (e.g., cancellations/solutions in response to a ground delay program)

Within the CDM model, the ATCSCC rations limited airport arrival resources while the users make the economic decisions. This model is consistent with the Free Flight concept where the Service Provider would intervene only when safety could be compromised.

The CDM program's participant functionality for TFM is structured and funded as depicted in Exhibit A-1. Funding for CDM.

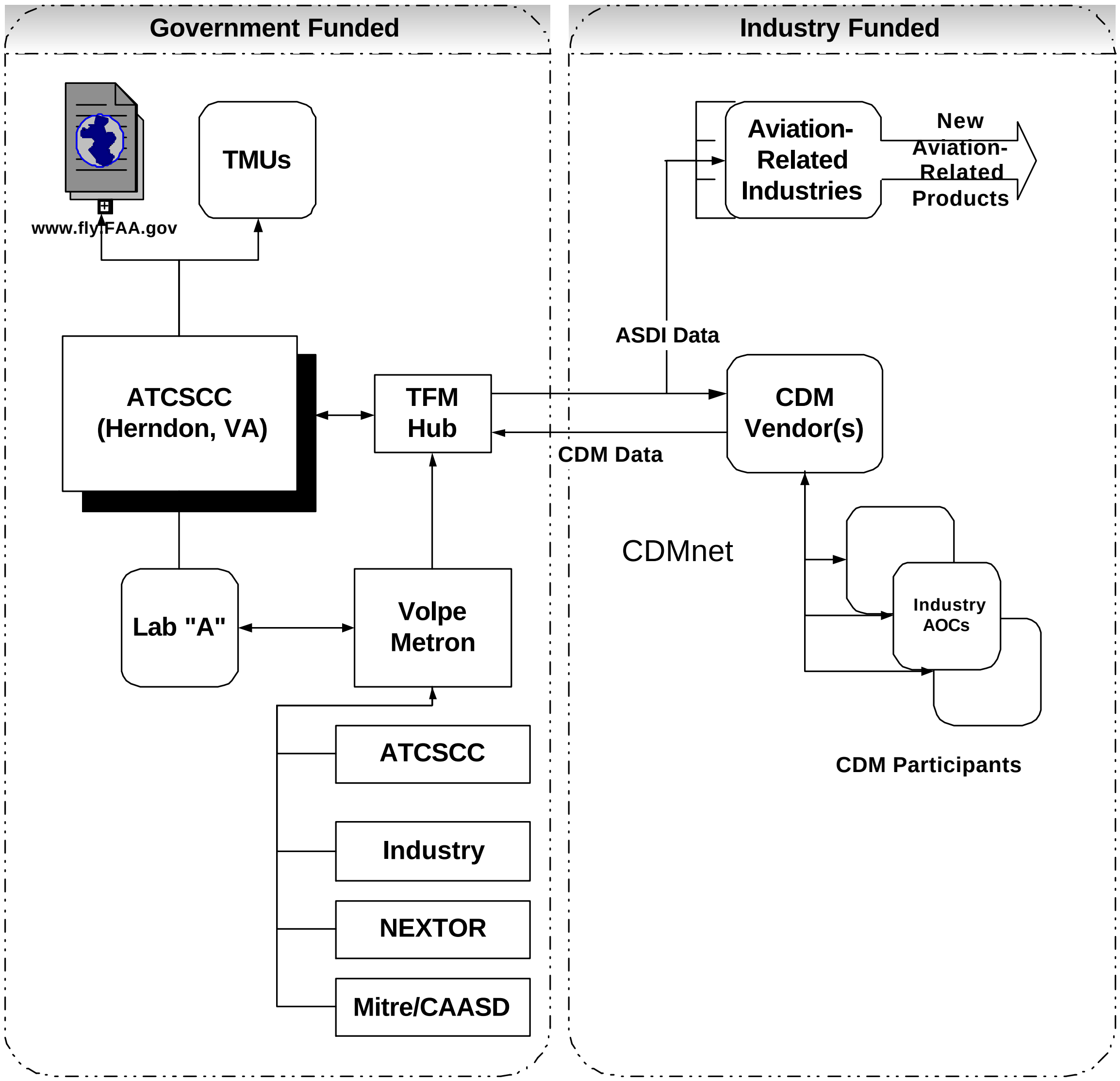

Exhibit A-1. Funding for CDM

A.3 How CDM Works

The key ingredients of a successful CDM program for Traffic Flow Management are:

- FAA/industry data collection/exchange network(s)
- Separate FAA and industry funding
- Extensive use of internet technology (e.g., http://www.fly.FAA.gov)
- A collection of discrete TFM/CDM capabilities
- Common displays and decision support software
- Extensive use of "shareware" where appropriate

- Distributed decision making
- FAA and industry reach consensus on the flow situation
- FAA defines constraints
- Industry optimizes own individual operation within constraints
- An appropriate division of government/industry responsibilities
- Performance analysis
- Near-real time and post-operational feedback

The most critical element required for collaboration is data exchange. Shared information creates a common situational awareness, which gives users increased participation in traffic management and allows all parties to reach a consensus during decision making. The CDM's Communications Sub-group designed an intranet communications link between AOC centers, the ATCSCC, and Volpe National Transportation Systems Center, called the AOCnet. The AOCnet was designed to replace existing communication links that were outdated and of limited bandwidth. ARINC, Inc., was hired to build the link and was the sole vendor. Several vendors now provides similar communications links. Collectively, these networks facilitate two-way data exchange of real-time information and are referred to as the CDMnet. The CDMnet supports Ground Delay Program Enhancement (GDPE), Aircraft Situational Display to Industry (ASDI), the expansion of information exchange, and future Collaborative Routing efforts between ATCSCC and the AOCs.

To answer the general question of how CDM would be applied to TFM, Exhibit A-2. CDM TFM Data Flows contrasts the old and new TFM data flows.

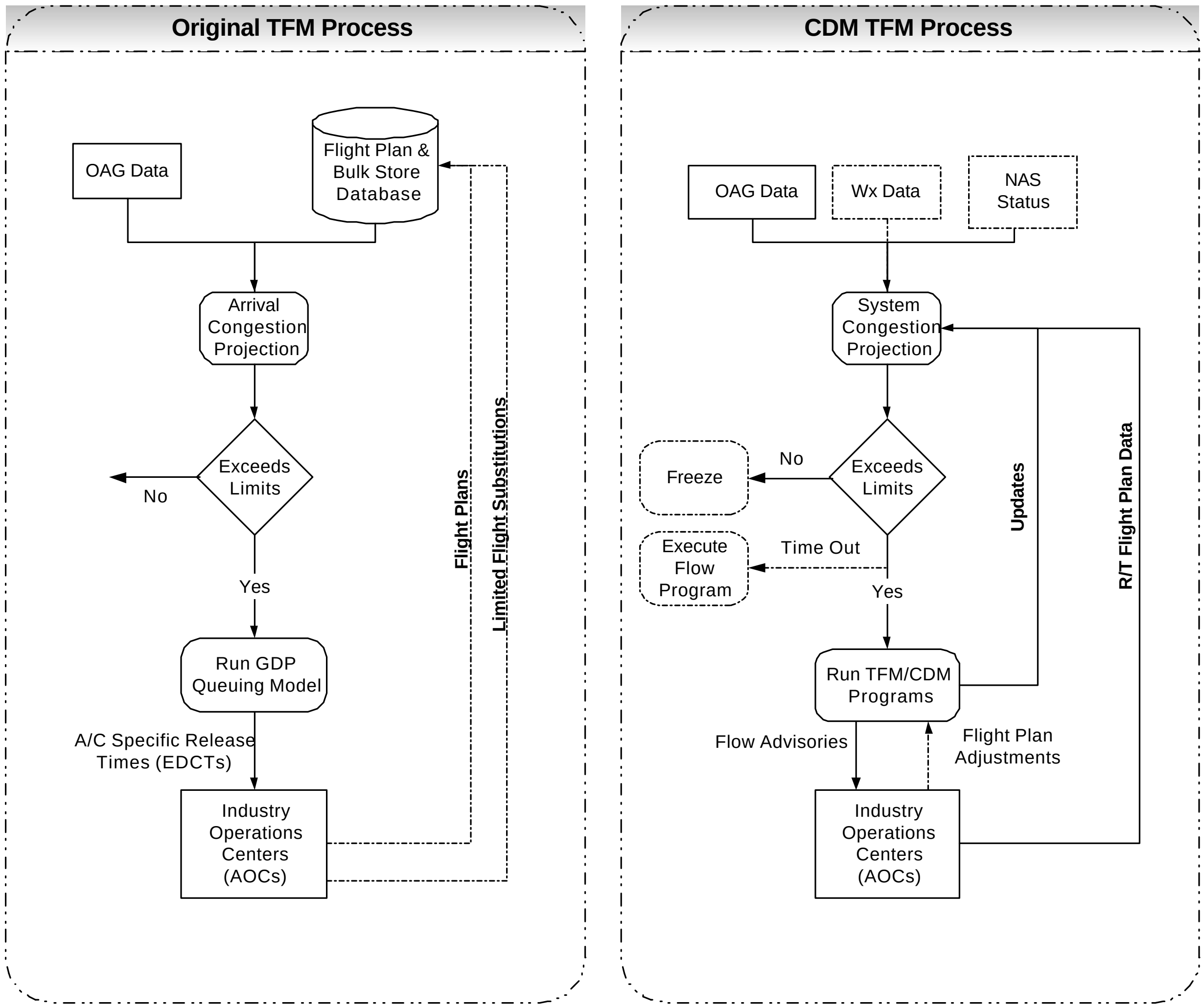

Exhibit A-2. CDM TFM Data Flows

Currently, the AOCs send in their operational schedules and any subsequent changes to those schedules via the CDMnet to Volpe. From there, the schedules are integrated and updates with NAS messages and other data. The integrated prediction of airport activity is then sent back to the AOCs and ATCSCC in the form of an Aggregate Demand List (ADL). ADLs are sent out approximately every 5 minutes. This means that the user's view is always current. Predictive accuracy tests between the dynamic CDM data and the FAA's Enhanced Traffic Management System (ETMS), which receives data from the Official Airline Guide, show the added benefit of continuously updated information.

The decision support software that displays information sent over the AOCnet is Flight Schedule Monitor (FSM), which was designed and developed by Metron Aviation, Inc. FSM incorporates suggestions for user interface and functionality from AOC and ATCSCC representatives. Created to interact effectively with ATCSCC's systems, FSM allows users to view NAS constraints in the same format as ATCSCC specialists, which means that users have the ability to assess the expected impacts of NAS constraints on operations by performing "what if" analyses to quickly explore alternative scenarios.

FSM displays airport arrival capacity versus demand information important to both AOC and ATCSCC personnel in both a timeline and graphical presentation. ATCSCC specialists monitor airports to determine any demand/capacity imbalances. If an imbalance exists, the specialist determines what action to take. It may be that flights need to be delayed on the ground to compensate for the reduced arrival capacity at an airport. FSM analyzes the effects of different Ground Delay Program parameters so specialists can view several alternatives in a matter of seconds. This allows specialists to find the best program to run: one that minimizes impact on air carrier operations and maximizes efficiency in the face of adverse conditions.

CDM procedures state that a GDP Advisory is sent to AOCs before a program actually is imposed. AOCs then have the opportunity to cancel, delay or create new flights according to their own operational and economic objectives. Once these actions are taken, ATCSCC receives the new information and determines whether the need for a program still exists

Aside from its use during GDP situations, FSM data also is used by the AOCs to manage operations on a regular basis. The data displayed allows AOCs operators to make fuel load decisions or predict airborne holding patters at an airport. This can help reduce diversions and keep operations running smoothly.

Past disincentives prevented airlines from sharing current scheduling information with the FAA. FSM removes these disincentives with sophisticated internal logic. Some of the problems and the ways they were addressed in FSM are discussed below.

A.3.1 Ration by Schedule (RBS)

RBS is the enabler of the data exchange. In the current traffic management system (ETMS), if an airline reported cancellations in advance of a GDP, those flights would be dropped from the database and the airline would not be able to use its assigned arrival slots for substitutions. If an airline reported a mechanical delay, ETMS would re-project its arrival time, and if a GDP were run, that flight would most likely receive an additional delay on top of its mechanical delay. These effects have become known as the "double penalty" issue. Although virtually all airlines involved in CDM agree that the schedule information they are asked to send to FAA would lead to better decision making, this double penalty issue represented a barrier; an impediment to implementing the data exchange. Airlines simply would and could not send in information that would produce clear adverse economic consequences. RBS resolves this disincentive.

The RBS concept is a simple one: When arrival capacity is reduced and limited arrival resources (arrival slots) must be rationed, for scheduled carriers the rationing should be based upon the original schedule, not current projections of demand. The RBS concept has been integrated into all versions of GDPs, including extensions, revisions and blanket programs (in the FSM system). The RBS concept is one of the fundamental cornerstones of the CDM program and represents a separation of the information used for decision making from the information used as the basis of resource rationing.

A.3.2 Compression

Compression, also known as bridging substitutions, is a process whereby unusable arrival slots are shifted in time so the owner can again use that slot. For example, an airline has two flights scheduled to arrive in EWR; flight one at 1300 and flight two at 1500. After a GDP is run flight one is assigned a 1400 arrival slot and flight two receives a 1700arrival slot. If flight is canceled, flight two cannot make use of the 1400arrival slot because it occurs before its scheduled arrival time of 1500. Compression will allow the vacated slot to move down to where flight two can make use of it.

There are some interesting mathematics associated with compression. In general, users with a small presence at an arrival airport are the primary beneficiaries of compression. It is these cases where there tend to be schedule gaps preventing the full use of the substitution process. There are also instances where an airline with a major presence at an airport can benefit from compression. This usually requires a significant number of cancellations before these block points are reached and compression is needed to fill in the holds. Note that whether compression is helpful in a specific instance is to some degree a function of the Airport Acceptance Rate (AAR). If, in the example above, the GDP had been run at a significantly lower AAR and flight one received a 2 hour delay with an arrival slot of 1500, then clearly flight one could be canceled and flight two could substitute into the 1500 slot with the existing substitution rules.

A.3.3 Control by CTAs (Controlled Time of Arrival)

This item is actually imbedded in the data exchange. Given an arrival slot, the user may determine its own departure time according to its own economic objectives. This departure time would become that flight's Estimated Departure Clearance Time (EDCT). A version of this feature is in effect with a new message known as ADJ (adjust), as part of the existing substitution process. The ADJ message permits users to replace the FAA estimate of en-route time (ETE) with its own, thereby selecting its own departure time. Eventually, Control by CTAs will be built into the new CDM message structure. The final version of Control by CTSs also requires the implementation of simplified substitution roles.

A.3.4 Simplified Substitutions

The existing substitution process can be somewhat cumbersome and difficult to use. In simplified substitutions, the need to identify specific pairs of exchanges or substitutions (e.g., flight one cancels and flight two is substituting into flight one's slot) is eliminated. Users will be allocated a set of arrival slots, and in the initial solution there will be an initial assignment of flights to slots. If a user cancels, delays or in anyway changes slot assignments, the user will simply report that, for example, flight two is now assigned to slot 1, flight three is assigned to slot 2, and so forth. The capability to conduct simplified substitutions is being embedded in the CDM message structure.

A.4 Benefits

An FAA organization, ASD-400, has been tasked with conducting benefits analysis of FAA programs. This organization is independent of the IPT which manages the CDM program. The results of the various exercises, statistical and simulation analyses were provided to ASD-400, which in turn conducted their own analysis, and used various formulas to reduce most of the benefits numbers and ensure a conservative calculation. Using projections in demand growth, the benefits were then computed over an eight-year time frame. ASD-400 concluded that the CDM elements (as described above) comprise a potential $2.6 billion reduction in costs to the airline industry through the year 2004. Including passenger value of time, as calculated by an established FAA formula, this number becomes $8.9 billion. Even considering airline investment costs that are needed (e.g., software systems to generate the CDM messages) a rough order of magnitude estimate of the cost of implementing full CDM functionality is somewhere in the $5 million range; making for a rather incredible benefit to cost ratio. There are no advanced technologies and no elaborate expensive systems in CDM. It's cheap, and the benefits appear substantial.

There are those who consider these calculations somewhat misleading, and not reflective of the true benefits of CDM. First, they don't account for improved planning on the part of the users that may result from the return flow of information. Second, they don't account for delay propagation. Third, they don't account for qualitative benefits, such as the improved scheduling flexibility associated with the simplified substitution process. But most importantly, there are those who suggest that the greatest benefit of CDM is that it is a clear, first step toward greater collaboration and information exchange; that it is breaking some of the cultural and institutional forces that have led to industry and government working not as partners, but as adversaries. Strong individuals in the FAA and the airline industry are working to change this; to bring in a new era of teamwork and cooperation. As one CDM representative once put it, "it's us, government and industry, together against the weather."

A.5 CDM 2003-2005

The focus of CDM is improved Traffic Flow Management and it would be more accurate to refer to CDM as Collaborative Traffic Flow Management (CTFM). CDM does not now, nor should it, deal with Air Traffic Separation.

CTFM is a process through which the operational and technical communities of NAS users and service providers work together to evolve the TFM system. CTFM is not a unique concept; it is an aviation application of the distributed planning sciences, information technology, and other by-products of the information age.

The 2003-2005 timeframe will be critical to the success of CTFM. The key is **evolution:** the nature of Traffic Flow Management and the uncertainties associated with strategic planning horizons necessitate a continuous evolution of procedures, tools, and infrastructure. The ultimate success will come when all NAS users participate in the process.

There are three key elements that will require support to ensure that CTFM evolves:

- Common Situational Awareness - Achieved by providing all players with a common display mechanism for all players to view the constraints in the NAS and a stable and robust communications infrastructure that facilitates information exchange
- Distributed Planning - The science of distributed planning requires some type of resource allocation mechanism. The system needs to provide predictability, equitability, be dynamic and interactive. The challenge is to develop a decision framework with clear roles and mechanisms, through which users may interact, infusing their own economic priorities into the allocation of resources. It is not always clear which decisions are best economically; the process must evolve over time.
- System impact Assessment/Performance Measurement - A comprehensive measurement system needs to be developed to provide a strong, transparent, and independent performance review and target-setting system.

This system should address all aspects of air traffic management including policy and planning, safety management, as well as economic aspects of services rendered. Key performance areas that should be measured:

- Safety
- Delays
- Cost Effectiveness
- Predictability
- Flight Efficiency
- Access
- Flexibility
- Availability
- Equity
- Human Factors

A.6 2003 – 2005 Evolution

A vision of CTFM's evolution during the 2003 - 2005 time frame is outlined below, by critical element.

- Common Situational Awareness
- CDMnet continues to evolve as needs arise. Bandwidth is increased to meet users needs
- ETMS communications requires a corresponding increase in bandwidth and perimeter as users needs dictate

- Two -way data exchange continued evolvement
- CRCT type functionality: Flow Constrained Areas is integrated with ETMS/TSD for national deployment
- Improved weather products: ITWS via the CDMnet continue evolution through 2005
- Distributed Planning
- Ration By Schedule in the en route environment
- Collaborative routing analog to GDP-E revisions to provide Dynamic, predictable adjustments to changing conditions
- Control by CTAs (the initial capability is in operation) process continues through 05.
- Modifications made to merge data to provide airport throughput predictor
- System Impact Assessment
- Ground Delay, Airborne delay, MIT, and reroute trade-off tool

During this time frame work would also continue on what can be referred to as the Collaborative Traffic Flow Management Toolkit. This toolkit consists of:

- An integrated and common (NAS users and FAA) set of tools for Arrival/Departure management and en-route constraint management
- A stable, robust FAA/NAS user communication infrastructure that provides for dynamic information exchange
- Distribution of constraint information and analytical measures of uncertainties associated with constraint/demand forecasts
- Common display mechanisms for NAS users and FAA (ATCSCC and Field Facilities)
- Equitable and efficient resource allocation mechanisms with user interaction
- Solid performance measurement capabilities to address uncertainties and guide the continued evolution of CTFM (CDM)

Mature capability by 2003-2005 will require considerable think tank design work. The recommended process is one of sustained evolution of capabilities using the “think a little, build a little, test a little” concept. CTFM in FFPI along with open ETMS have provided many opportunities that allow for economies of scale during development and deployment. The infrastructure and knowledge should be leveraged to lower risks associated with the capabilities.

Additional TFM bandwidth is paramount to the success of many of the items listed above. The network is operating at maximum capacity now. It is essential to ensure that this element of the process has the capacity for providing all NAS elements critical to Collaborative Traffic Flow Management now and in the future.

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